EDITION B

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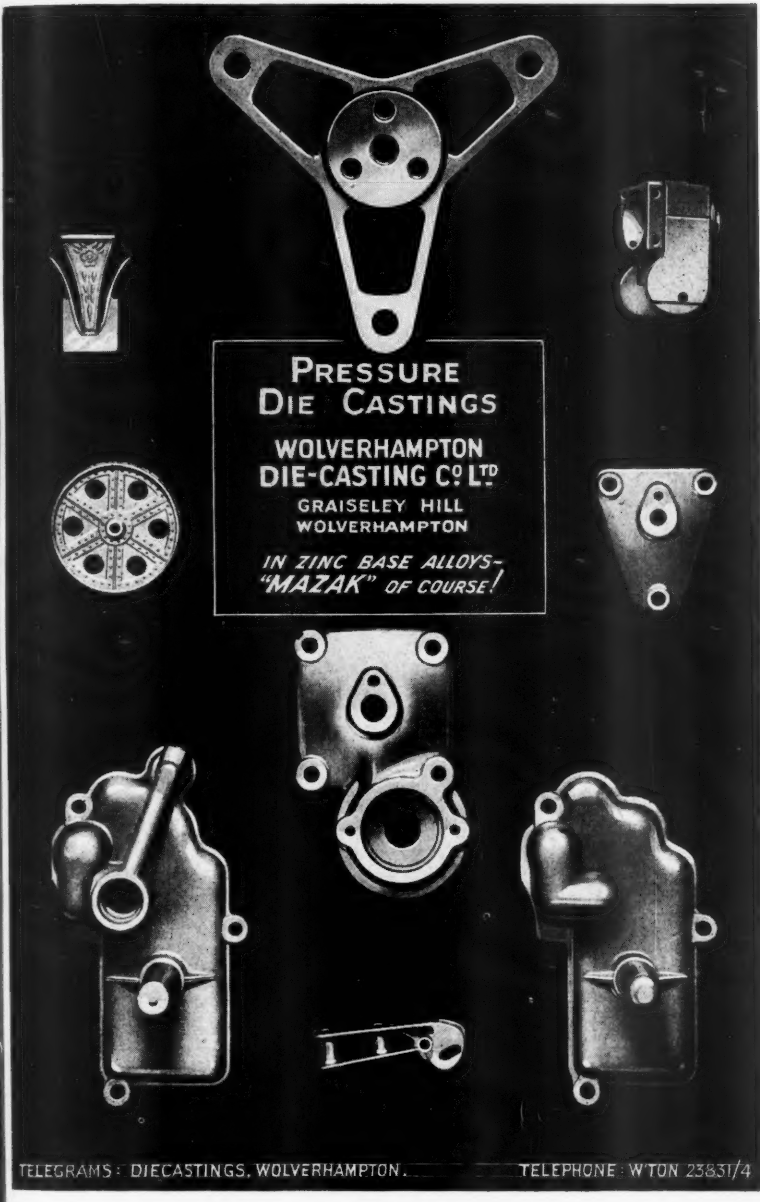
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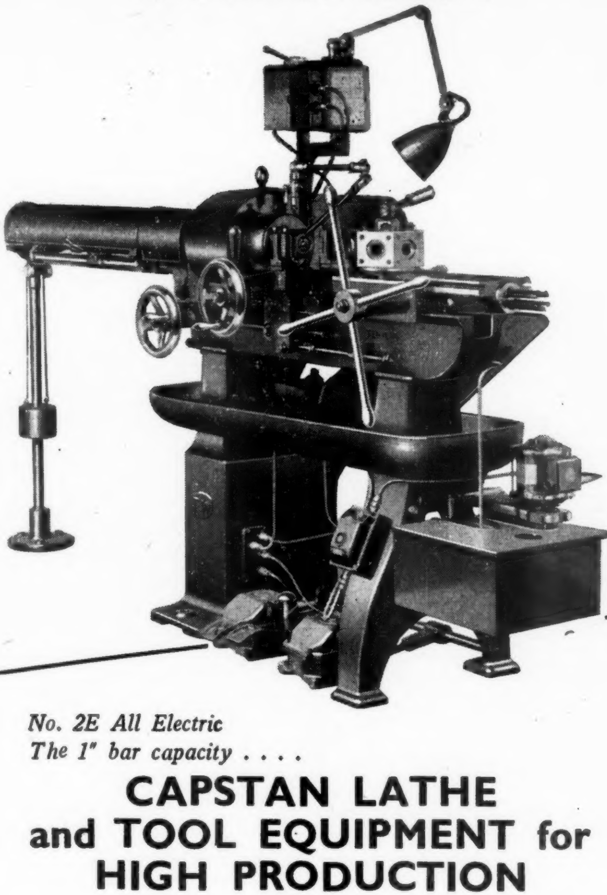

INDEX TO ADVERTISEMENTS

As a war-time measure the advertisement section of this Journal is now published in two editions, A *and* B. *Advertisers' announcements only appear in one edition each month, advertisements in edition* A *alternating with those in edition* B *the following month. This Index gives the page number and edition in which the advertisements appear for the current month.*

The fact that goods made of raw materials in short supply owing to war conditions are advertised in "The Journal" should not be taken as an indication that they are necessarily available for export.

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JUNE, 1943

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INSTITUTION NOTES

June 1943

Council Meeting.

The Council met at Birmingham on Friday, June 25, 1943, the following being present: The Lord Sempill, presiding, Messrs. H. A. Hartley, J. A. Hannay, M. H. Taylor, J. Kenworthy, J. S. Daniels, A. Bailey, J. W. Berry, H. J. Gibbons, G. H. Hales, J. R. Pearson, D. Burgess, J. W. Davies, F. W. Halliwell, J. Blackshaw, C. W. Mustill, R. Kirchner, J. France, H. Drane, W. F. Dormer, E. Percy Edwards, F. C. White, E. W. Hancock, J. H. Bingham.

Personal.

Mr. H. W. Harpeı and Mr. H. S. Broome, have recently been awarded the M.B.E.

G. F. Galloway, our Assistant Director of the Research Department has been successful in obtaining his Doctor's degree.

Obituary.

We deeply regret to learn of the death of the following members of the Institution. Mr. H. S. Locker (Member), Col. H. McLaren (Member), Captain A. C. Burgoine (Member), Lieut. J. Moffatt (Graduate), Mr. P. Hinds (Affiliate).

Captain Burgoine was a prominent member of the Institution and was President of the Western Section from 1938 to 1940.

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Transfers.

From Associate Member to Full Member ; A. A. J. Francis, W. Goacher, C. Halse, J. T. Knight, A. G. Wybron.

From Intermediate Associate Member to Associate Member : A. B. Armstrong, L. E. Barker, N. A. Maskell, W. Mayall, R. J. Schroeder, D. G. Watkinson.

From Graduate to Intermediate Associate Member : W. Fishburn, E. G. Nunn, J. B. Scott, H. J. Wright.

From Intermediate Associate Member to Associate : Major F. Walker.

From Graduate to Associate Member : L. Brown, R. G. W. Bliss, A. T. Coote, J. R. Young.

From Student to Graduate : R. Blore, W. G. Carter, E. Gillibrand, C. H. Parker, W. Robinson, G. M. Smallwood, D. K. Wood.

MACHINING EFFICIENCY AND LEAD-BEARING STEELS

In preparing this article, the author considers that a useful purpose would be served in discussing the empirical laws which govern the art of machining with turning tools. The development of these laws has been the subject of immense amount of research work over many years, which work has been published from time to time in the technical press. It is felt that a discussion of the main facts emerging from the acceptance of these empirical laws would be helpful to those responsible for machine-shop practice. In any case, some knowledge of these laws is necessary in order that the advantages of leaded steels may be properly assessed.

At the beginning of this century, Taylor published before the American Institute of Mechanical Engineers, his monumental work on the art of machining metal.[1] Its salient features can be summarised in the statement that the problem of machining involves the consideration of some 12 variables amongst which are cutting speed, depth of cut, feed, coolant, tool steel, cutting angles, profile of tool, type of cutting operation, etc., and that the effect of these variables may be expressed by mathematical relationships.

Since that date, a great deal of experimental work recorded in literature, more or less confirms the general principles evolved by Taylor, and while there are still differences of opinion, with regard to the magnitude of the effect of certain of the variables mentioned above, on machining efficiency, one may consider that the following major rules apply to the machining of steel within certain limits.

(a) All other conditions being equal, cutting speed varies inversely as the tool life raised to a certain power.

(b) For same tool life and cutting condition, cutting speed varies inversely as some power of chip thickness (instead of feed as originally proposed by Taylor).

(c) For same tool life and cutting conditions, cutting speed varies inversely as some power of the chip width (as distinct from depth of cut originally proposed).

(d) For same tool life, feed and depth of cut, etc., cutting speed varies directly with the "machinability index" of the material being cut, directly as the value of the coolant used varies directly as the quality of the material from which the tool is made, its heat treatment, etc., and also varies with the effective top rake employed, etc.

It must be emphasised that the above relations between cutting speed and one variable, are based on the assumption that all the other variables are maintained constant for the purpose of evaluating the relationship. The above empirical laws can be combined in the following empirical equation :—

$$S = \frac{K_1 \times K_2}{t^x \times l^y \times T^z} \qquad \text{EQUATION 1.}$$

Where S = Cutting speed in feet per minute.

K_1 = A constant called "machinability index" of the material being cut.

Where K_2 = Constant representing values for the tool material, top rake, nature of coolant, type of cutting operation, etc.

t = Chip thickness in inches obtained from theoretical chip section.

l = Chip width in inches obtained also from theoretical chip section.

T = Tool life in minutes.

x y z are exponentials.

Note, that according to Equation 1, if we maintain identical cutting conditions apart from speed, then when changing over from one material to another, the cutting speed will vary directly as the machinability index of the material being cut, in order to maintain the same tool life. Thus machine production rates will vary in like manner.

Curves showing the relation between cutting speed and tool life for a variety of steels have been quoted in the *Journal* of the Institution of Production Engineers.[2] If the curves are plotted with logarithmic axes, then the curves obtained become staight lines for all practical purposes thereby further confirming the validity of the empirical relation quoted above.

It has been observed, however, that while the laws so enumerated hold good for most steels operating at fairly high values of feed, they may not operate with the same degree of accuracy for extremely light feeds, of the order of .001/.002 in., etc. Furthermore, at low cutting speeds, information has been published indicating an erratic relationship between cutting speed and tool life.[3] The purpose of this article is to discuss machining efficiency and leaded steels, as far as it relates to turning tools for repetition work carried out on modern autos and capstans, and for this work the normal cutting speeds employed exceed values which are sufficiently low to cause serious failure of the empirical relationships enumerated.

It is also recorded that there is a small change in the values of certain of the exponentials in Equation 1, depending on whether

light feeds or medium heavy feeds are being employed. For ordinary auto work, the value of the feeds used comes within the category of light feed.

From data recorded by other investigators,[4] it is worth observing that for auto repetition work under the conditions normally prevailing approximate values of the exponentials for Equation 1 are as follows :—

$x = \frac{2}{3}$.
$y = 2.3 \times$ chip thickness in inches.
$z = .09/.1$ (using coolant).

The profound effect on tool life of increasing or decreasing the cutting speed, all other conditions remaining constant, does not appear to be fully appreciated. Making use of the approximate value of the exponential z for T in Equation 1 the following Table I showing the effect of varying the cutting speed is worthy of consideration.

Table I		Table II		Table III	
Cutting speed (F.P.M.)	*Tool life (min.)*	*Feed (inches/min.)*	*Tool life (min.)*	*Depth of cut (inches) (at .005 in. feed)*	*Tool life (min.)*
125	10	.014	10	—	—
107	50	.011	50	.230	90
100	100	.010	100	.100	100
93	200	.009	200	.043	110
90	300	.0085	300	—	—

Note :—The values of cutting speed and tool life are entirely arbitrary, and are merely for illustration.

In a similar manner, changing the chip thickness by altering the feed materially alters the tool life, all other conditions being kept constant, as per illustrative Table II above.

Similarly, altering the depth of cut (i.e. chip width) is shown in Table III from which it will be seen that the effect is relatively small.

It will be agreed therefore that the correct choice of cutting speed and feed will rank as of major importance in the setting up of an automatic to run at optimum efficiency.

An alteration of chip thickness, and therefore an alteration to tool life can be arrived at by changing the angle subtended between the cutting edge of the turning tool, and the axis of the material being cut. Further, the introduction of a nose radius reduces average chip thickness.

For example, when that angle is 90° as in a simple knife tool the chip thickness equals the feed. If however, we grind the tool to give an angle of 45°, the true chip thickness equals feed $\times$ sine $45° =$ $.707 \times$ feed, thereby giving a reduction of chip thickness of 30%

which will prolong tool life very considerably. Alternatively of course, cutting speed could be increased while maintaining the original tool life. The effect of altering the angle between cutting edge and work piece, and the introduction of a radius is illustrated in Table IV. Assuming cutting conditions for a sharp cornered knife tool of A = 90°, are datum values, then

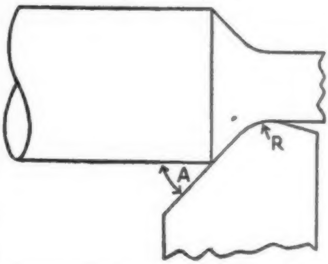


Table IV

Where Radius is Nil and angle A =	60°	45°
Multiply cutting speed by	1.1	1.2
or feed by	1.1	1.4
or tool life by	2.2	6
Where R = ½ depth of cut and angle A =	60°	45°
Multiply cutting speed by	1.2	1.3
or feed by	1.3	1.4
or tool life by	6	10

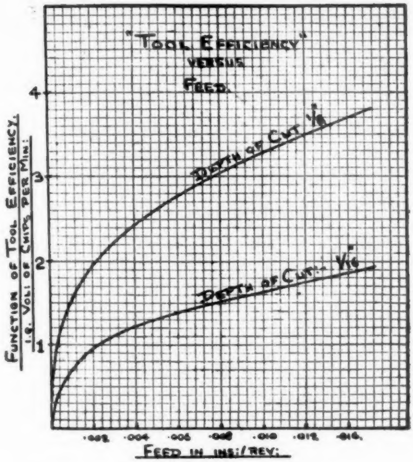
The problem of attaining maximum machining efficiency can be approached from another angle by computing an expression to evaluate "tool efficiency," which can be described as the rate of removal of metal for a standard tool life, and will therefore be proportional to the rate of production of machined parts. Utilising Equation 1 and making tool life constant, then

$$\begin{aligned} \text{Tool efficiency} &= \text{Vol. of chip/min. for a standard tool life.} \\ &= S \times t \times l. \\ &= \text{constant} \times t^{\cdot 33} \times l^{1\cdot 2\cdot 3t} \end{aligned}$$

Graph No. 1 illustrates the tool efficiency versus feed for various depths of cut. It will be observed that the efficiency rises rapidly from *extremely* light feeds to light feeds, for example, .003 in. and thereafter the gain in efficiency is less with further increase in feed. One observes therefore that the higher the feed which may be used, circumstances permitting, the better will be the tool efficiency, and therefore the better the output rate of finished parts per hour of efficient tool life.

From Graph No. 1 it will be noted that the depth of cut does not seriously alter the shape of the tool efficiency curve, nor the point of inflection. There are of course, other considerations which must be borne in mind when setting up a job on an automatic at high efficiency, but in general, the following observations are worthy of emphasis as far as they apply to turning tools.

(a) Select the heaviest feed which can be tolerated with due regard to surface finish, and thrust on spindle, etc. ; usually depth of cut is controlled by stock and finished size.



GRAPH 1.

(b) Where possible, use a tool with side cutting angle and nose radius.

(c) Select a cutting speed to give tool life which will maintain satisfactory machine efficiency.

(d) Apply adequate supply of coolant.[2]

(e) It is reported that chatter effects will be minimised by avoiding chip width greater than 25 × chip thickness, and the use of a nose radius of ½ of depth of cut is recommended. Chip length control is not so important, with free-cutting steels as with the tougher machining steels.[1]

(f) Effective top rake using H.S steel should with advantage be 10/15° for steels normally machined in autos.

(g) Tools should be jig ground, smooth finished, sharp edged and consistent correct angles.

Specific Cutting Pressure.

It has been stated in the past that if the pressure operating tangentially at the cutting edge of a turning tool be divided by the area of the chip, then the value known as the "specific cutting pressure" is obtained, which is reasonably constant, for any one material, even under varying cutting conditions as regards feed, speed, depth of cut, etc. This is not the case however, as at light feeds, the specific cutting pressure is materially higher, and falls

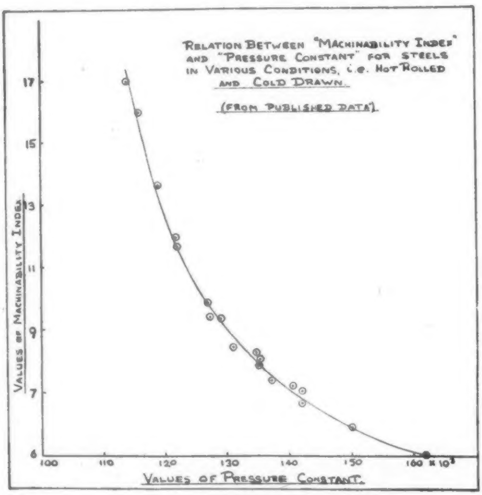
with increase in feed, speed, etc.[5] According to A.S.M.E., a relationship has been derived as follows :—

$$P_t = K_p, K_r, t^{\cdot 78}, l^{1\cdot 1}, \qquad \textbf{EQUATION 2}$$

Where P_t = tangential chip pressure (lbs.)
K_p = constant depending on material
K_r = 1 — .0075 × top rake
t = chip thickness in inches
l = chip width in inches

Later, graphs will demonstrate that the factor for top rake, and the exponential for feed (or chip thickness) are not strictly correct at light feeds (< .003 in.).

It is a rule that as the machinability index (Equation 1) of a steel increases, the pressure constant falls. An approximate relationship between the two is given in Graph No. 2 based on A.S.M.E. data.



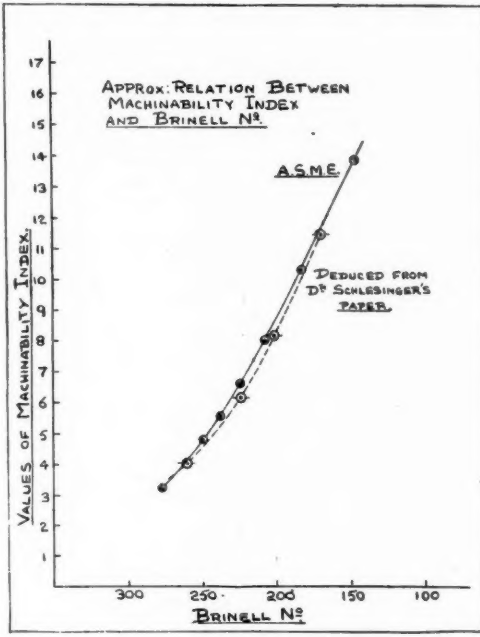
GRAPH 2.

The relation is not however a simple hyperbolic one, and the curve applies primarily to hot rolled or normalised steel.

The exact relation for conditions of light feed is rather a difficult one, as the formula proposed by A.S.M.E. is not strictly true for light feeds. An effort has been made to provide a means for transposing from pressure constant values to machinability indices later on in this article.

Material to be Cut.

Hitherto we have only considered empirical laws and facts relating to machining, without considering the machining capacity of various steel materials in common use. There is plenty of published information on the relative machining values of the different steels. Usually these values represent the "machining index" (K_1) in



GRAPH 3.

Equation 1 for different steels. Dr. Schlesinger and others, report that there is some relation between Brinell hardness of the steel being machined and its machinability index.[(2)] Referring to Dr. Schlesinger's paper, the graph showing the relation between Brinell number and machinability can be re-plotted to show the relation between machinability index, and the inverse of Brinell number. Graph No. 3 shows that the machinability index varies nearly inversely as the Brinell number, and that data published by A.S.M.E. and Dr. Schlesinger approximate very closely.

This relation is very interesting, but unfortunately it is not

strictly valid as there are steels of similar Brinell characteristics which differ considerably in machining quality. The author has in mind steels which have been cold drawn and work hardened during that process, and also steels containing lead, the addition of which, does not alter the Brinell hardness but considerably increases machinability index, etc. As a rule steels which are cold drawn, possess a machinability index at least equal to that of the same steel in the as rolled or normalised condition. Experience shows that it is approximately true to assume that cold drawn steels of varying composition differ amongst themselves as regards machinability, in the same manner as the same steels in the normalised or heat treated condition. It is the final object of this article to discuss the aforementioned lead-bearing steels which contain a small quantity of metallic lead (.15/.30%). which steels have been produced in this country during the last three years during which period they have given considerable service by rendering possible considerable increases in the rate of production of many articles. The principle characteristics of lead-bearing steels are[11]:

(A) They show the same mechanical properties at room temperature as lead-free steels.

(B) Their improved machining property is considerable.

(C) Their cost is such that they are highly economic in use.

(D) They can be produced in wide range of qualities.

That the mechanical properties of leaded steels are similar to those of lead-free steels, but otherwise similar composition, is indicated in Table 5 ; and it is not proposed to labour this point further, as leaded steels of various grades have received wide approval against standard specifications.

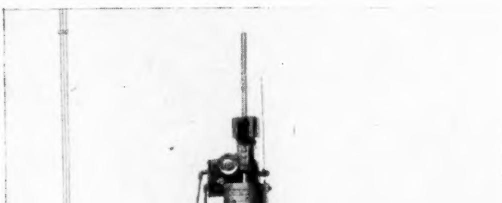
Table V.—MECHANICAL TEST DATA

Quality	*Condition*		*Analysis*						*Mechanical Tests*			
		C	Mn	S.	P.	Ni.	Cr.	Pb.	T.S.	E.	R.A.	Izod
Free Cutting ½" dia.	Drawn	.13	.95	.235	.051	—	—	—	36.8	24.1	49.0	—
Leadbearing ,,	,,	.12	.98	.226	.067	—	—	.20	37.0	23.0	50.1	—
3.S.1. ⅝" diam.	Drawn	.16	.74	.042	.05	—	—	—	43.3	18.1	54.1	—
,, Leadbearing	,,	.17	.69	.033	.027	—	—	.22	44.9	16.3	58.0	—
40% C. 1 5/16" a/f. hex.	Norm.	.40	.61	.035	.028	—	—	—	36.7	26.0	43.4	24/25
Leadbearing ,, ,,	,,	.42	.61	.034	.033	—	—	.20	39.0	25.0	41.0	25/27
2.S.2. 1" dia.	Heat treated	.37	1.45	.008	.02	.28 Mo.	—	—	62.0	22.7	60.7	57/59
Leadbearing ,, ,,	,, ,,	.37	1.45	.008	.02	.28	—	.17	60.1	23.6	60.7	55/57
						Ni.	Cr.					
Ni/Cr. 1¼"dia.	,, ,,	.41	.74	.028	.013	1.73	.65	—	67.5	18.0	56.5	55/60
Leadbearing ,,	,, ,,	.42	.25	.022	.012	1.74	.65	.17	63.5	18.0	53.0	52/57

From a machining point of view, lead-bearing steels possess the following characteristics :—

(1) They require less energy to generate a chip.
(2) The temperature of the chip machined is less, and therfore the tool cuts cooler.
(3) There is a tendency for lead-bearing steels to produce shorter chips which in many cases in an advantage. These steels will therefore give increased tool life (by reducing the rate of wear of the tool), or alternatievly they may be run at higher speeds or higher feeds, or a combination of both.

Published literature on the subject (see bibliography), contains recorded data on the subject of improved drillability ; improved sawability, etc., and also in one case, gives details of observed tool temperatures during a turning operation.[6] The drilling and sawing tests indicate between 25 and 40% advantage in favour of lead-bearing steels.



MACHINE A

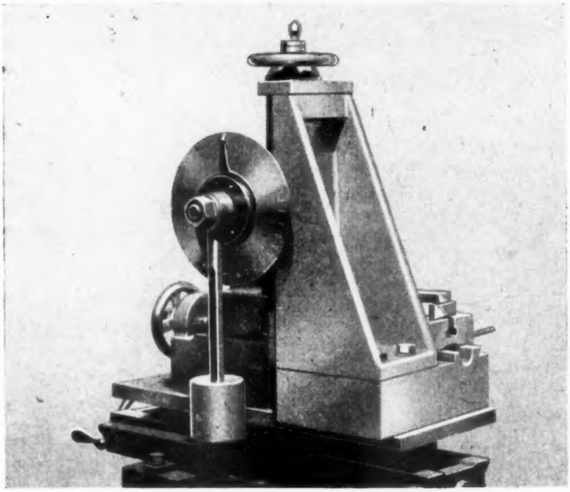
While it is agreed that drilling and sawing tests act as an indication as to how the material will respond to machining in the lathe, it is difficult to correlate drilling and sawing test results with values of machinability index, or pressure constant as previously discussed, the latter bearing some direct mathematical connections with machine efficiency. The author has carried out a series of experiments to determine pressure constant, and in some cases, machinability indices on leaded and non-leaded steels, the results of which it is proposed to deal herewith. The tests were carried out on two machines, a brief description of which is as follows :

Machine (A).—A vertical spindle machine which can be utilised as a drilling machine or a lathe, provided with range of feeds from .001/.015 in. per rev., and with choice of cutting speeds from 20 f.p.m. up to 600 f.p.m., provided with a roller box, whose shank is mounted co-axially with the spindle. Using a tangential tool, the tangential thrust at the cutting edge is measured by spring beam dynamometer, end thrust on the tool is measured by a special dynamometer mounted between the weight feed cross-head, and the lead-screw nut, while radial thrust is very low, not worth measuring, and is taken up by the rollers.

Machine (B).—Consists of a pendulum energised shaft mounted in a crosshead and carrying a cutting tool, the edge of which describes a circular orbit, the energy in the pendulum being indicated by circular graduated dial on the pendulum side of the shaft. By means of vertical and horizontal traversing feed screws, the tool can be made to cut a chip from steel specimen mounted in vice. This machine is built on similar lines to the machine used and described by Airey & Oxford (see reference 10).

With machine (A), I have been able to carry out tests for relative drilling capacity between lead-bearing and lead-free steels, the determination of cutting speed tool life relationships the determination of the relative machinability indices of leaded and non-leaded steels, and also the measurement of tangential cutting pressure, and the horse power or energy consumed under varying conditions of feed, speed, depth of cut, etc.

Note that determinations of energy and horse power consumption on machine (A) are under continuous cutting conditions, while on machine (B) the conditions are equivalent to intermittent cutting. The method of operating machine (B) incidentally was to use a tool with straight cutting edge, at right angles to the axis of the tool with sharp corners with top rake, so that it would be equivalent to a knife tool in action. In order to simulate ordinary turning conditions, tests have been carried out cutting across the grain of the material, with one corner only of the tool buried in the work, cuts being generated by operating the hand-wheel control of the



MACHINE B

vertical feed screws, thereby giving a chip of uniform thickness and for precise accuracy, weighing the chips produced rather than relying on the nominal feed given by the feed screw of the machine, and compensating for friction in the shaft carrying tool and pendulum.

The main features of the machines are shown in the accompanying photographs.

Some of the experimental results obtained on the machine are detailed below, comprising drilling, tool wear *v.* cutting speed and power consumption tests. Since steels in practice vary in composition fairly widely within the usual purchasing ranges of analysis, the machinability also shows appreciable variations. In order to obtain as nearly as possible truly comparative results, leaded and non-leaded steels from the same cast have been compared, or steels of almost identical composition and treatment have been chosen.

Drilling Test Results

⅜ in. standard H.S.S. twist drill. Standard ground.
Load on drill—138 lb.

Quality	*Condition of Material*	*Drilling Rate (ins./min)*	*% Improvement*
Ordinary Freecutting (BSS.32.Gr.4)	Hot Rolled	2.15	40
Leadbearing " "	" "	3.0	
Ordinary Mild Steel (11/16 carbon)	" "	1.5	33
Leadbearing " " " "	" "	2.0	
Ordinary Medium Carbon (.3% Carb.)	" "	1.62	34
Leadbearing Medium Carbon (.3% Carb.)	" "	2.15	
Ordinary medium Carbon (.40 Carbon)	" "	1.37	32
Leadbearing medium carbon (.40 Carbon)	" "	1.82	
Stainless 18/8 } ¼ in. drill at 124 lb. load	Softened	1.50	25
Leadbearing }	"	1.87	

It will be noted that the average gain in drilling efficiency for lead-bearing steels is 25/40% and that the values quoted confirm those already reported in the technical press.(7) Much more important, are the results of experiments to determine :—

(A) Do lead-bearing steels obey the same empirical laws of machining as lead-free steels.

(B) What are the relative values of machinability index and pressure constants as compared with lead-free steel.

Tests to determine relation between cutting speed and tool life are given in the table below :

Table VI

Determination of Tool life exponential "Z" (Eq. 1).

Conditions of Test

Tool :—18% W H.S.S. tangential, no radius, 15° top rake.
Cut :— 3/32 in. deep. Feed .005 in./rev. Coolant :—Oil.

No. 1 TEST.—Material : Leadbearing Mang./Moly. 2.S.2. Heat treated.

Analysis												
C.	Mn.	Mo.	Pb.	S.	P.	Si.	T.S.	Brin.	Izod	Cutting speed	Tool life	Val. of Z
.36	1.52	.31	.17	.011	.029	.196	61.1 tons	255	53/59 ft.lb.	125 f.p.m. 137 f.p.m.	41 min. 16.2 min.	.098

No. 2 TEST.—Material : Leadbearing Nickel. Chrome 4.S.11. Heat treated.

Analysis													
C.	Mn.	Ni.	Cr.	Pb.	S.	P.	Si.	T.S.	Brin.	Izod	Cutting speed	Tool life	Val. of Z
.33	.52	3.2	.90	.16	.012	.019	.17	58.7	269	72/75	122 f.p.m. 150 f.p.m.	22.5 3.2	0.11

No. 3 TEST on Ordinary heat treated Mang./Moly. for comparison.

Conditions :—14% W. H.S.S. tangential tool. No radius.
15° top rake. Cut .080 in. Feed .00275 in. /rev.
Oil coolant.

Cutting speed	*Tool life*	*Value of Z*
167 f.p.m.	26.7 min.	
177 f.p.m.	14.5 min.	= 0.10

Note that the values of "tool life index" "Z" so obtained are similar to the value .09/.10 reported by A.S.M.E., Boston and others for ordinary steels. The effect of altering chip thickness (by introducing side cutting edge angles is illustrated in Table VII.

Note chip thickness for test No. 2 is the same as chip thickness for test No. 1 and making allowance for the slightly lower cutting speed the tool lives are identical. Note also that in test No. 2, the amount of metal removed before tool breakdown is 60% greater than is the case with test No. 1, thereby demonstrating the advantage of using a side cutting edge angle if possible, as it leads to greater machining efficiency.

It seems therefore that the empirical laws correlating chip thickness, tool life and cutting speed, substantially apply to leaded steel.

Table VII

Conditions of Test.						*Analysis*		
				C.	Mn.	Sul.	Phos.	Pb.
Material :—Lead Bearing Mild Steel 1½ in. diameter				.15	.82	.028	.021	.20

Mechanical properties :—

Tensile	*Elongation*	*R.A.*	*Izod*	*Brinell*
28.7 tons	26.5	65.8	82,80,86	140

Machining conditions :—20% W. H. S. steel tangential tools, oil coolant
Depth of cut .070 in.

TEST No. 1.

Tool ground as a knife tool sharp cornered, 15° top rake.

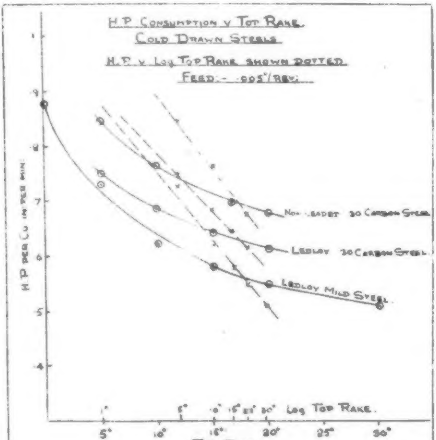
Feed	*Cutting speed*	*Tool life*
.005 in.	260 f.p.m.	40 min.

TEST No. 2.

Tangential tool sharp cornered, 15° top rake, but with side cutting angle 52°

Feed	*Cutting speed*	*Tool life*
.0082 in.	255 f.p.m.	44 min.

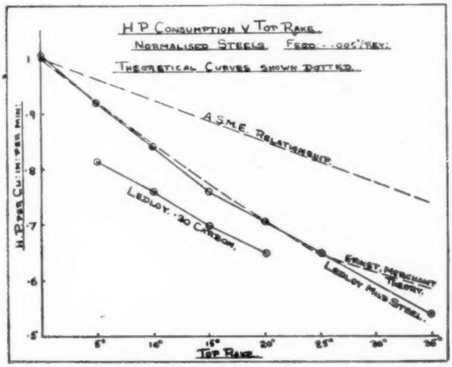
Experiments have been carried out to determine the effect of top rake, feed, depth of cut on power consumed in machining, which latter is proportional to chip pressure and pressure constant, in order to determine whether leaded and non-leaded steels obey similar laws such as Equation 2. Graphs No. 4 and 5 illustrate the reduction in



GRAPH 4.

energy consumption which results from increasing the top rake. These tests were carried out on machine (B) with one cutting edge buried in the work cut transversely to simulate ordinary machining conditions.

It is observed that the curves for cold drawn mild steel exhibited in Graph No. 4 are not similar to the curves obtained in Graph No. 5 for normalised and hot rolled specimens. There is not space in this article to deal with this matter in full, but the author would like to point out that the effect of top rake as indicated by A.S.M.E. Equation 2 is shown in the dotted line in Graph No. 5 and the



GRAPH 5.

linear relationship apparently applies to the normalised steels but not the cold drawn steels of Graph No. 4. At the same time there is plotted as a further dotted line in Graph No. 5 the effect of top rake according to Ernst Merchant theory [9]. Reverting to Graph No. 4 for cold drawn steels, it is interesting to observe that if the top rake is plotted on logarithmic axis, substantially straight lines are obtained of the form

$$y = C - a \log r.$$

Where r = rake angle.

Y = energy consumed per cu. inch.

C. and a are constants.

This law is approximately correct up to about 25 or 30° top rake but fails at higher values. Mr. A. S. Kenneford has previously suggested to the author the following relationship between reduction in energy consumption with increase in top rake, namely

$$p = a \log r$$

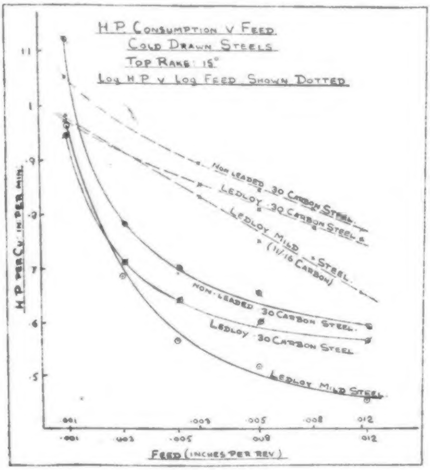
Where p = % decrease in energy

a = constant

r = top rake

The evidence available therefore on the effect of top rake is somewhat conflicting, but as the purpose of this article is to compare leaded steels with non-leaded, the author feels that the evidence submitted indicates that it is justifiable to compare the two qualities of steel under consideration, under conditions of identical feed and top rake, for determining relative machining quality.

Graph No. 6 illustrates the effect of feed on energy consumption the curves also being plotted on the same graph on a log scale. In the latter case, an approximate straight line results, except at very



GRAPH 6.

low values of feed. One can assume therefore that the factor for chip thickness or feed in Equation 2 is correct in principle, although the value of the exponential may not be strictly true.

It is submitted that the evidence furnished supports the view that leaded steels obey similar laws to non-leaded steels in general, and that therefore the value of leaded steels may be assessed by comparing the value of machinability indices obtained by experiment or pressure constant, similarly derived. In Table VIII, there are

reported the results of the determination of several machinability indices for leaded and non-leaded steels, pressure constants, etc.

Table VIII

Machinability Indices and Pressure Constants For Leaded and Non-Leaded Steels

Type	*Quality*	*Condition*	*Machining conditions*		*Depth*	† *Press. Constant* × 10^{-3}	% *Gain*	*Machining Index*	% * *Improvement*
			Feed	*Rake*					
Free Cut.	32.Gr.4.	Normalised	.0027	15°	.100	81	—	—	—
Leadbearing	,,	,,	.0027	15°	.100	74	8½	—	37‡
M. Steel........	.12/.14C	,,	.005	15°	.100	150	—	—	—
Leadbearing	,,	,,	.005	—	—	131	12½	—	34‡
Med. Carb...	.30 C	Cold drawn	.008	15°	.125	120	—	7.0*	—
Leadbearing	,,	,, ,,	.008	15°	.125	106	11½	8.8*	26
Carb.Steel....	.40 C.	Hot rolled	.0027	5°	.12	139	—	—	—
Leadbearing	,,	,, ,,	.0027	5°	.12	124	11½	—	45‡
Man. Moly...	2.S.2.	Heat treated	.0027	15°	.09	155	—	—	—
Leadbearing	,,	,, ,,	.0027	15°	.09	136	12½	—	42‡
Ni. Chrome..	4.S.11	,, ,,	.005	15°	.06	216	—	3.5*	—
Leadbearing	,,	,, ,,	.005	15°	.06	171	19½	4.8*	37
Mang. Moly.	.2.S.2.	,, ,,	.005	15°	.06	154	—	3.7*	—
Leadbearing	,,	,, ,,	.005	15°	.06	134	16	4.9*	32

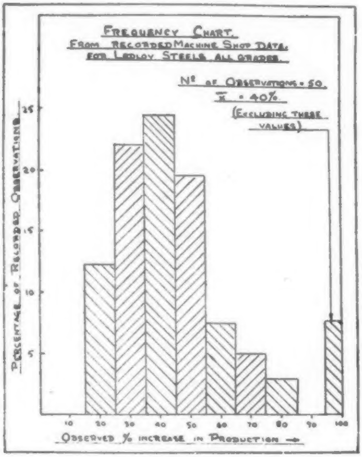
* Actual values by experiment.
‡ Estimated values approx. only.
† Computed from Equation 2.

The percentage increase in machinability index or reduction of pressure constant which indicates the advantage shown by the leaded steel over its non-leaded equivalent are tabulated above. If one refers to Graph No. 2 it will be seen that at high values of pressure constant a marginal difference in value of pressure constant, say 10% is equivalent to a somewhat greater percentage difference in machinability constant. On the other hand at the lower values of pressure constant, the same 10% difference corresponds with a very much higher percentage difference in machinability index.

Making use of conversion factors derived in this manner, the pressure constant differences shown in favour of lead-bearing steels have been roughly converted to increase in " machinability index " as shown in the right hand column of Table VIII. It will be observed that the improvement in machinability index, allowing for the conversion mentioned above, is of the order of 25/45%. In other words, one may justifiably assume that when using leaded steels of the type discussed, cutting speeds may be increased by the like amount for the same tool life, and therefore production will increase *pro-rata*. At the same time the alternative to increase in cutting speed is increase in feed calculated from the foregoing formula (Equation 1). It can be shown that the feeds and therefore production rates may be increased from 50/80%.

The author has had the opportunity of examining a considerable number of authentic reports from users of leaded steels, sufficient in number to enable a frequency chart of increased production to be made. This chart reproduced herewith covers the results of 50

different reports dealing with articles which vary widely in character, in quality of lead-bearing steel used, and type of machine on which they were manufactured. It is probable also that machine-shop conditions and practice vary widely. The frequency chart shows an average recorded increase of production of about 40% with



GRAPH 7.

a range of 20/100%. Even if the latter value is ignored the author submits that this frequency chart record tends to substantiate the estimated values of increased production deduced from experimental machining test data.

In an article of this nature, space does not permit me to deal adequately with possible theories underlying the undoubtedly marked improved machining efficiency of leaded steels, or to discuss in detail, the fundamental differences between steels in the cold drawn or normalised or heat treated, or as rolled conditions.

Summing up, the evidence contained in this article, lead-bearing steels do not require specialised technique for their manipulation in machining operations, and by intelligent selection of accelerated cutting speeds and feeds, they will yield important increases of output, and improve the production efficiency of the average machine shop.

The author wishes to thank Messrs. Exors. of James Mills, Ltd. and Messrs. Ledloy Limited for permission to publish much of the information contained herein, and Mr. A. G. Sanders for the practical work and preparation of the graphs.

BIBLIOGRAPHY

(1) Transactions A.S.M.E. 1907, "On the Art of Cutting Metals," by F. W. Taylor.

(2) Journal of the Institution of Production Engineers, February, 1942. by Dr. G. Schlesinger.

(3) Report on "Action of Cutting Tools," etc., by Dr. Dempster Smith and A. Leigh.
Institute of Mechanical Engineers, March, 1925.

(4) Journal of the A.S.M.E. (Mechanical Engineering), 1937, Vol. 59.

(5) Manchester Association of Engineers, Paper, March 28, 1924 ". . . Cutting trials with extremely fine cuts" by Dr. Dempster Smith and I. Hay.

(6) Revue de Metallurgie Memoirs, 1940, Vol. 37. February. " Lead-bearing Steels " by L. Guillet.

(7) Metals and Alloys, 1938. Vol. 10, pages 68/73.
Iron Age, November 17, 1938. Vol. 142, pages 28/33.

(8) "Study of Cutting Oils"—Machine Shop Magazine, March, 1943, page 42. O. W. Boston.

(9) "Chip Formation, Friction and High Quality Machined Surfaces" by Ernst & Merchant, A.S.M. 1940.

(10) Engineering, 1939, Vol. 148 and
Journal of the Institute of Metals—1939, vol. LXV, page 79, "Laboratory test for machinability" by A. S. Kenneford.
Transac. Amer. Soc. Mech. Eng. 1921, 43, 549, Airey & Oxford.

(11) Automobile Engineer, March, 1939, page 92.
Engineer, March 3, 1939, page 274.
Engineering, March 31, 1939, page 381.
Hardware Trades Journal, March 17, 1939, page 526.
Iron and Coal T. R., March 10, 1939, page 456.
Machinery, February 9, 1939, page 606.
,, February 23, 1939, page 664.
,, May 11, 1939, page 172.
Machinist, February 25, 1939, page 40E.
,, March 4, 1939, page 59E.
Mechanical World, February 24, page 208.
,, ,, March 3, page 222.
Metallurgia, May 1939, July 1939.
Iron Age, Vol. 142, pages 28/33.
Metals & Alloys, Vol. 10, pages 68/73.

Research Department: Production Engineering Abstracts

(Edited by the Director af Research)

ANNEALING, CASEHARDENING, HARDENING.

Single or Double Hardening for Motor Car Transmission Gear Wheels made of Case Hardening Steel. [*H. Glaubitz, ATZ (Germany), Vol. 46, No. 1, January, 1943, p. 9*].

Double hardening for gear wheels is as its name implies consists of a process involving **2** quenches, a typical treatment for a case hardening steel being as follows :—

	Case hardening	927°C.
	Cool to	871°C.
1st.	Quench in oil, reheat to	805°C.
2nd.	Quench in oil, temper to	155°C.

It has been claimed that this process is essential in order to obtain a sufficiently firm grain structure both of the case hardened layer and the internal core.

In the manufacture of gear wheels, however, the double hardening process has proved very expensive on account of the greater risk of warping necessitating an increase in the amount of grinding required.

There is no doubt that single hardening would reduce warping troubles.

The difficulty is however to provide sufficient hardness of the core without the risk of overheating the case and coarsening the grain structure of the latter unduly. (This may lead to embrittlement and must be avoided especially in gears).

From German and American experiments it appears that satisfactory results can be obtained by the single hardening process for smaller wheels and relatively thin case (1 mm.) if the quenching temperature is dropped by about 40°C. below the normal (i.e. 830 against 870°C.) great care must be taken that the parts are at a uniform temperature before quenching and the rate of cooling from the case hardening to the quenching temperature must also be accurately controlled. The exact heat treatment will vary with the type of steel employed and will have to be determined by experiment once the right temperature conditions have been determined, there will be no difficulty of reproducing the correct conditions, thanks to the excellent thermometric equipment of the modern metallurgist and the close conformity to specification of modern steels.

According to the author, it was lack of such equipment and variation in steel composition which led to the introduction of the less sensitive double hardening process about 20 years ago.

It appears that with some more research, rough hardening will also become general for larger wheels.

(Communicated by D.S.R. Ministry of Aircraft Production).

Cyaniding of High Speed Tool Steels. [*H. Schaumann, Der Betrieb (Germany), Vol. 21, No. 9, September, 1942, p. 375*].

Cyaniding is a special surface hardening process carried out in a salt bath at temperatures between 500 and 550°C. It is only applicable to high speed tool steels, with a tempering temperature of the same order. The steels more-over should not be temper sensitive and the process cannot be applied to ordinary tool steels.

The bath consists mainly of a mixture of Sodium and potassium cyanide, the temperature of which is kept about 20°C. below the tempering temperature of the steel. During the immersion, which lasts from 15 to 45 minutes, gaseous cyanogen compound are evolved which necessitates efficient ventilation. The nitrided layer is very thin (20-30 μ.) but of considerable hardness (1100-1200 Vickers Units).

Satisfactory nitriding by this process can only be carried out if the surface of the tool is in good condition, and has not been decarbonised by previous rehardening. The high speed steels employed should be hardened in such a way that a fine grain structure has become established before the cyaniding process is applied.

It appears that dimensional changes in the tool only become important when the tempering temperature of the particular steel is reached or exceeded.

On the other hand the hardness of the nitrided layer generally increases with the temperature of the cyanide bath. It is therefore essential for best results that the tempering temperature of the particular steel be known accurately and work with a bath temperature about 20-30°C. below this.

Excessive bath temperature or prolonged immersion leads to a reduction in the hardeness of the nitrided layer. In this case the only remedy is annealing at 800-850°C. in the absence of air and fresh hardening. The article concludes with some data on the increase in tool life which can be obtained by proper application of the cyaniding process. In the case of spiral drills subjected to considerable wear, the life can be increased by at least 50%. For broaches and milling cutters even greater improvements have been noted. In the case of broaches, a 20 fold increase in life has been obtained in certain cases.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

COMBUSTION, FURNACE.

(1) The Ajax-Tama Wyatt Induction Melting Furnace ; (2) Induction Furnace for Melting Aluminium Alloys. (*Metals and Alloys, February, 1943, Vol. 17, No. 2, p. 283*).

Details of design, operation, advantages and limitations of this low-frequency induction furnace which has been developed for melting Al alloys. See also Brit. Pat. Spec. 536, 108, by M. and M. Tama.

(*Communicated by the British Non-Ferrous Metals Research Association*)

EMPLOYEES, WORKMEN, APPRENTICES.

Industrial Relations, Organisation and Personnel Administration, by D. B. Harris. (*Personnel, U.S.A., March, 1943, Vol. 19, No. 5, p. 674*).

The functions of an industrial relations organisation and those of a personnel department. Personnel administration is but one major phase of industrial relations. The industrial relations organisation of one large Company are described, examined in detail the distinct functions and operations of the organisation's Personnel Section.

Developing Professional Standards for Personnel Executives, by C. A. Drake. (*Personnel, U.S.A., March, 1943, Vol. 19, No. 5, p. 646*).

As personnel management demands an ever-widening body of specialised knowledge, there is a pressing need for determining the personal qualifications, the training and the experience which its practitioners should possess. Such standards must be formulated cooperatively by employers, personnel executives and educators. Five commonly accepted criteria of a profession are cited and greater adherence urged to the requirements they impose. Only by developing to full professional stature can managers of human relations in industry achieve maximum effectiveness.

FOUNDRY, MOULDING, PATTERNS.

Plugging Porous Castings with Plastic. [*A. Rehbock, Z.V.D.I. (Germany), Vol. 86, No. 7 and 8, February, 1943, p. 126*].

A high degree of gas-tightness is frequently required of castings employed in the construction of refrigeration plant. To ensure this is not always possible as metal castings are frequently permeated with fine pores with the result that it becomes necessary to increase the wall-thickness of the castings to a considerable extent if they are to be rendered adequately gas-tight. Lacquer coatings hitherto used to overcome this difficulty have not always proved satisfactory under actual working conditions. Two processes in this connection have recently been adopted whereby plastic material is used for plugging these porous cavities. This plastic material is applied to the pores of the casting either in the form of a solution or as a liquid which subsequently hardens. The plastic materials most suitable for this purpose are polyvinylchloride and polystyrol.

In the first process an impregnating solution PCU 3 is used. This consists of a solution of Igelit PCU of a certain grade of polymerisation mixed with suitable solvents. The viscosity and adhesion of this solution are of a consistency required for efficiently sealing up the porous cavities. The impregnation is best carried out in a special impregnating plant, the solution being applied to the pores under suction and pressure. On heating to 80-90°C. the solvent evaporates. The plastic is resistant to acid and lye as well as to the cooling agents usually employed for refrigeration (with the exception of sulphuric acid and methylchloride).

In the second process monostyrol in thinly liquid state is applied to the pores. This synthetic resin polymerises on heating the casting and applying pressure. The polystyrol thus obtained is for refrigeration purposes still only resistant to ammonia.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

HYDRAULICS.

Hydraulically Operated Clutches, by R. Waring-Brown. (*Mechanical World, May 7, 1943, Vol. 113, No. 2940, p. 489, 7 figs.*).

A review of friction clutch contruction, embodying hydraulic operation and emphasising remote control possibilities. Hydraulic intensifier. Hydraulically actuated single plate clutch. Shoe type hydraulically actuated clutch. Hydraulically actuated turbine clutch. Hydraulically actuated machine tool clutch. Hydraulically actuated two speed clutch. Remote hydraulic clutch control.

The Hydraulic Operation of Lathes for the Production of Shells, by W. Littlejohn Philip. (*Engineering, May 14, 1943, Vol. 155, No. 4035, p. 396, 19 figs.*).

Hydraulic power was distributed to all the machines in the factory from a central pumping plant. A somewhat special feature of the author's system is that no pumping water is needed for the return movements of the saddles and slides. These are brought back by an enclosed hydraulic circuit in which the correct pressure is maintained by a small accumulator. The hydraulic fluid is similar to the coolant used for some of the cutting tools. 18-pdr. Plant. In this machine the shells were bored and turned from the solid bar, and then parted off by a tool carried by a vertical hydraulically operated ram. The total time for all turning and boring operations, including parting-off, ready for the base plate and copper band, was 15.5 minutes. 9.2 in. Howitzer plant. The figures show all machine tools hydraulically driven and the complete plan of operation. Tooling times, time from floor to floor and metal removed are given for each cycle. The total floor-to-floor time for all machining operations on the 9.2 in. shell, including its adaptor, was under 2½ hours per shell.

MACHINE ELEMENTS.

Bearings and Bearing Corrosion. [*L. Raymond, J.S.A.E.,* (*U.S.A.*) *Vol. 50, No. 12, December, 1942, p. 533*].

" Babbitt " bearings have been accepted generally as the preferred bearing metal for by far the great majority of bearing applications due to their low friction characteristics, conformability, embeddability, bonding characteristics, and corrosion resistance. However, under conditions of increased bearing loads and higher oil temperatures, babbitt bearing of conventional design are susceptible to fatigue failure, resulting in breaking out of the bearing metal In such cases, protection has been sought in bearing metals with improved high-temperature strength characteristics, the bearing alloys resorted to being copper-lead, cadmium-silver, cadmium-nickel, and hardened high lead (98% lead), as well as other high-lead alloys. The most widely used of these newer types of precision bearings has been the copper-lead. A typical proximate analysis of this bearing metal is 65% copper, 35% lead.

Unfortunately such bearings, unlike babbitts are corroded by the products of oil oxidation the lead being dissolved and the remaining copper shell breaking away from the backing.

Data presented in this paper indicate the bearing corrosion problem to be fairly straightforward in that :

1. Corrosion of copper-lead bearings specifically can be reduced by improving the fineness of the microstructure ;

2. All bearings appear to be added greatly by reduction of operating temperatures; and

3. Treating the corrodible bearings by special processes, such as indium plating greatly increases their corrosion resistance.

However, anomalies are cited which indicate that bearing and oil combinations do not behave in relatively the same manner in all engines.

Different types of corrosion may occur in different engines or bearings, or a mechanical or assembly defect, rather than a corrosive oil, may be responsible for bearing failure. The appearance of a bearing frequently fails to indicate the reason for its failure, and more thorough investigation must be made.

In his conclusion the author emphasises that the field of bearing corrosion still has large unexplored areas.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

Flexible Couplings, by R. Waring-Brown. (*Power Transmission, May, 1943, Vol. 12, No. 136, p. 265, 7 figs.*).

Outlining pin type shaft coupling design, where flexibility in power transmission is an essential requirement. Loads on coupling pin. Compressive stress on coupling pin. Compression in bush. Flexible bushes for coupling. Flexible coupling. Coupling pins.

Bearing Seals. (*Power Transmission, May, 1943, Vol. 12, No. 136, p. 239, 29 figs.*).

A bearing requires attention and protection. The attention consists of proper lubrication, and the protection is afforded by means of correctly designed seals. Felt seals. Labyrinth seals. Oil seals. Seals for vertical shafts. Seals for special purposes.

MACHINING. MACHINE TOOLS.

The Effect of Hardness on the Machineability of Six Alloy Steels. (*O. W. Boston, 24th Annual Convention of the A.S.M. (U.S.A.) October, 1942*).

The effect of hardness on the machinability of steel was studied by means of a series of turning tool-life tests on six alloy steels in the quenched and tempered condition. The tool material, tool shape, size of cut, and cutting fluid represented commercial practice. The results show marked sensitivity of machinability to hardness in all six of the types of alloy steel tested. These steels gave a wide range of machinability ratings, particularly at high hardness. However, the difference in machinability between two heats of the same type of steel was as great as the range covered by the six types. There appears to be a direct correlation of hardenability with machinability of the harder steels.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

Metal Cutting with Abrasive Wheels, by W. B. Heinz. (*Trans. Amer. Soc. Mech. Eng., January, 1943, p. 21*).

A mathematical study, based on the pure geometry of cutting wheel action, undertaken in order to predict how an abrasive wheel should be operated to provide the best combination of production rate and total production before it wears out. A subsequent line of experimental research is suggested.

(*Communicated by the British Non-Ferrous Metals Research Association*).

CHIPLESS MACHINING.

Formability of Aluminium Alloys Used in Aircraft Fabrication, by G. A. Brewer. (*Automotive and Aviation, Ind., December 15, 1942, Vol. 87, No. 12, p. 32*).

The commonly used Alcoa Al alloys have been arranged in order of their ability to withstand pressworking operations involving (1) stretching, (2) bending, (3) shrinking. Author discusses these forming operations.

(*Communicated by the British Non-Ferrous Metals Research Association*).

The Uses and Advantages of DropS tamps used in conjunction with soft metal tools, by A. T. Pierce. (*Sheet Metal Industries, May, 1943, Vol. 17, No. 193, p. 831, 9 figs.*).

The introduction of air-controlled drop stamps has revolutionised the pressing of light alloys. Air-controlled machines have two main advantages

in comparison with ordinary rope drop hammers. (1) All operations can be easily controlled ; and (2) the sensitiveness of the mechanism enables the operator "without fatigue" to move the ram rapidly and with as much pressure as the work requires. Examples : (1) Material, 20 G. duralumin. Production time, 20 minutes. Previous production time by hand, four to five hours. (2) Material, 18 G.L.4 (no heat treatment). Production time, 30 minutes on drop stamp. Previous production time by hand, 15 to 20 hours. (3) Air duct. Material, 20 G.L.4 (no heat treatment). Production time, one hour complete. By hand, the time was 25 to 30 hours. The usual procedure is to make a wood or plaster pattern. Another method is to form a series of template to given ordinances, which are held together in position by rods and the cavities filled in with plaster. Having completed the patterns, the moulding, casting and foundry procedure may be considered. The material used for the dies is usually zinc alloy and for the punches antimonial lead. Tool breakage. Casting the punch. Placing tools on the hammer. Fixing.

Forging 75 and 90 mm. shell bodies. (*The Machinist, Armament Section, May 1, 1943, Vol. 87, No. 2. p. 12E, 30 figs.*).

Rejects are held below 0.5% of total production by close inspection during forging and by adjustable water-cooled dies that control concentricity and wall thickness of the shell bodies. Stock for shell forgings is flame cut from mill-length bars. Billets are heated in Tate Jones rotary-hearth furnaces fired by gas. Furnace capacity is 400 billets, which are heated to the forging temperatures of 2,230°F. in one hour and 50 minutes. Operation plan : (1) billet centred for piercing ; (2) billet pierced ; (3) billet ejected. Pierced shell reamed to remove scale before placing in bottoming die. Shell bottomed in drawing press. Draw and strip shell.

MANUFACTURING METHODS.

Gang Riveting—A New Method of Riveting Employed by Curtiss-Wright Corporation. [*Curtiss Fly Leaf (U.S.A.), Vol. 25, No. 4, September/October, 1942, p. 19*].

An important new short-cut in riveting the thin aluminium skin covering on Curtiss Helldiver dive-bombers and Seagull scouting planes has been developed at the Ohio plant of the Curtiss-Wright Corporation. It is claimed that this new method of riveting has reduced the number of hours required for the operation by 70%.

Formerly each rivet was installed in a separate operation. A single rivet was placed in its hole. One employee operated the rivet gun ; a second acted as "bucker." Because the operation was done by hand, many times rivets were driven in non-uniformly and had to be re-worked or again the skin was "ringed" by the incorrect angle of the rivet gun, making it necessary to replace the entire skin section. The new system employs a "gang riveter" which can drive up to nine rivets in a single operation. Instead of holding up a fuselage fixture on the assembly lines until the skin has been applied, the thin aluminium covering is now assembled on a bench. The fixture is free to move down the line for other operations which formerly had to wait. When it is completed, the skin is then installed on the fuselage in a large section rather than piece by piece. Gang riveting has also eliminated "ringing" of the skin due to the uniform operation angle of the gang riveter.

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Automatic Uniform Rolling-in of Small Tubes. (*F. F. Fisher and E. T. Cope, Trans. A.S.M.E., Vol. 65, No. 1, January, 1943, p. 53*).

An entirely new technique of rolling-in tubes is described. This employs the familiar tools with the addition of appropriate thrust collars. The tool is entered to its full depth into the tube at the beginning of the operation and the current limiting relay automatically stops the rolling by shutting off the current to the motor when the joint has been expanded by the correct amount as determined previously by laboratory tests on sample joints. This relay is not in the circuit during the starting of the motor or during the backing out of the tool, a very important new development. In this technique the elongation is compensated for in whole or in part by the stretching of the tube during the first stage of the operation, that in which the tube end is enlarged to fit the tube hole.

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SMALL TOOLS.

Carbide Inserted Tooth Milling Cutters having Negative Rakes. (*Machinery, May 6, 1943, Vol. 62, No. 1595, p. 501, 2 figs.*).

By using a negative rake, much higher cutting speeds and rates of traverse can be employed, and the surface finish and accuracy obtained compares favourably with surface ground work. The figure shows a 6 in. diameter, 1½ in. wide, side and face milling cutter, having 16 teeth tipped with tungsten-carbide, with 10° negative helical and side angles, 4° top rake and 0° side relief. With this cutter, a first cut was made on a mild steel bar with a cutter speed of 443 r.p.m., that is 696 feet per minute, with a feed of 24 inches per minute, and $^1/_{16}$ in. depth of cut. The machine employed was equipped with a 25 h.p. motor and soluble oil was used as a cutting fluid. An 8 in. diameter face milling cutter having 24 teeth tipped with tungsten carbide was tested on mild steel with a peripheral cutting speed of 1,300 feet per minute, feed 0.024 in. per revolution, and depth of cut 0.025 in. The surface finish of the work is like a mirror. The machined surface was true to within 0.0002 in.

The Lay-out of Circular Form Tools, by H. Galliner. (*Machinery, April 29, 1943, Vol. 62, No. 1594, p. 463, 10 figs.*).

Illustration how the clearance angle can become zero. Modification to the side faces of the tool to reduce rubbing effect. Tool with helical side relief to reduce rubbing.

The Centre Line and the Position of the Cutting by Tool, Geo. Schlesinger. (*Machinery, May 27, 1943, Vol 62, No. 1598, p. 570, 13 figs.*).

The problem is discussed impartially and a solution found observing (1) the design of the tool, (2) the design of the machine tool, and (3) the action of the tool and its deflection under stress. Single cutting tools used on lathes and planing machines. The planer (I) the ordinary straight tool; the goose-neck tool. (1) for a finishing cut the deflection of the tool, (2) for a roughing cut. The tendency to dig in. Lathes (II). The cutting action externally and internally differs considerably. Furthermore, the toolposts are of quite a different design. The American tool-post. The ordinary toolpost with strong screws, The deflected tool moves into the piece, it may be positioned above, below or exactly on the centre line. The tool above the centreline, however, is always pushed backwards (compression); below the centre line it is pulled forward (tension). As long as the backward force T_B pushes (+) the tool away from the work digging-in will not occur. Below the centre line there is a pulling(—) action. The dangerous influence of backlash. Adjust the lathe tool above the centre line for external turning, and below the centre line for internal turning. Use the gooseneck toolholder adjusted on the centre line for parting and threading operations. The correct shape of the workpiece is produced with the deflected tool All machines ought to be fitted with an independent gauge which allows the adjustment of the tool to the centre line, above or below it.

The Influence of Workpiece Height Position in Centreless Grinding, by P. Grodzinski. (*Machinery, May 20, 1943, Vol, 62, No. 1597, p. 546, 3 figs.*).

The position of the workpiece relative to the centres of the two grinding wheels has a decisive influence on the accuracy of the roundness produced. The optimum roundness of workpiece is obtained when the tangents of the contact points include an angle of between 5 and 20 deg. Diagram showing the position of workpiece relative to the wheels of a centreless grinding machine. A formula (and graphs) is developed which contains the radii of workpiece, main abrasive and regulating abrasive and allows to calculate the setting angle.

SURFACE QUALITY, SURFACE TREATMENT.

The Surface Protection of Magnesium Alloys, by N. Parkinson and J. W. Cuthbertson. (*J. Inst. Metals, March, 1943, Vol. 69, No. 3, p. 109*).

AM503 (Mg with 2 Mn) can be effectively protected against corrosion by electrolytic treatment in hot 5% chromic acid using a.c., or a.c. with superimposed d.c. The protective film was found to consist largely of a mixture of oxides of Cr. and Mn. Mg and the alloy A8 (Mg with 8A1, ½Zn) cannot be effectively protected in this way or by direct anodising in chromic acid.

(*Communicated by the British Non-Ferrous Metals Research Association*).

Hard Chromium Plating and some of its Practical Applications, by Harry M. Dean. (*The Australasian Engineer, January 7, 1943, Vol. 43, No. 320, p. 13, 3 figs.*).

History of chromium. Nature of hard chromium deposits. Plating vat and cells and method of connecting in series. Method of connecting cells in parallel Experience has shown that an alloy of 6.8 per cent antimonial lead makes a satisfactory anode. Composition of electrolytes. Table showing comparative results using plated and unplated tools. Points to be observed. Cost of hard plating.

Chemical Protective Treatment and Cleansing Methods in Aircraft Production. [*R. Sanders, J.S.A.E. (U.S.A.), Vol. 51, No. 1, January, 1943, p. 23, Transactions*].

The author also deals with the problem of Cadmium plating on steel, copper and brass. Before any paint is applied to such deposits, the surface should be chromatised or phosphatised. Phosphoric acid compounds can also be applied to raw steel to retard corrosion and improve paint adhesion.

Successful spot welding also requires careful surface cleaning prior to the welding operation, since dirt or oxide affect the contact resistance and contaminate the electrod electrodes.

In this case the cleansing agent usually contains hydrofluoric acid which may present a health hazard. It is interesting to note that a phosphoric acid compound (Koldweld) has been developed lately which is generally effective and contains no aggressively active acid or virluent poison. Use of this type of compound consists in a single cold dip, eliminating the use of hot caustic etch or alkaline solution.

Another development has been a compound in jelly form for treatment of sections which are too large to submerge in solution. This viscous compound is painted over the area and wiped off after one minute with a cloth damped with clean water. Spot welding can then be carried out satisfactorily.

(*Communicated by D.S.R. Ministry of Aircraft Production*).

TECHNICAL EDUCATION.

Training Men and Women for Time Study, by David D. Garvey. (*Personnel, U.S.A., March, 1943, Vol. 19, No. 5, p. 693*).

More and more serious is becoming the plight of time study departments, which, handicapped though they are by a shortage of manpower, must nonetheless expand their facilities to keep pace with a tremendous increase in production. The author describes how Wright Aeronautical Corporation redesigned its time study training programme to bring its time study department up to ten times its former strength. Under the new stream-lined programme men and women are trained in the essentials of time study in eight or nine weeks.

WELDING, BRAZING, SOLDERING.

Arc Welding of Magnesium Alloys, by W. S. Loose and A. R. Orban. (*Welding May, 1943, Vol. XI, No. 6, p. 235, 4 figs.*).

The recent development of a practical process for the arc welding of magnesium has provided an important new tool for the fabrication of structures from these light, strong alloys. Helium arc welding process. Manual arc welding. Automatic arc welding. The tungsten electrode. Range of currents allowable for different size tungsten electrodes. Helium cups. Effect of welding variables. Corrosion. Heat treating and ageing. Standard arc-welding machines of the direct current type have been found quite satisfactory for welding magnesium. Reversed polarity is always used in welding magnesium alloys. Helium, the protecting gas shroud for the arc, is perhaps the most expensive item in the new method of joining magnesium alloy. The metal, when making butt or tee welds, should have as close a fit-up as it is possible to make for consistently strong joints and even penetration of weld metal. Due to the relatively high coefficient of thermal expansion of magnesium, elimination of warpage is one of the greatest problems confronted in arc welding this metal. Consequently all parts should be well jigged and clamped prior to welding. Tolerances within plus or minus 0.040 in. may be held within reasonable accuracy in arc welding. Importance of arc welding magnesium alloys.

The Reclamation of Cutting Tools by Arc Welding, by J. R. Treadwell. (*Machinery, May 6, 1943, Vol. 62, No. 1595, p. 494, 4 figs.*).

Some experiments as to the possibilities of reclamation by welding with the metallic arc. About 85% of reclaimed tools have proved to be successful. Fractured side and face milling cutter (5 in. dia. × ½ in. side). Welding procedure. Jig for setting twist drills true during welding. Fabrication of a spot facing cutter using mild steel as the base. The high speed steel pieces ½ in. by $^3/_{16}$ in. by $^3/_{16}$ in. were welded on to the mild steel with a light fillet on each side. Repair of a high speed steel pull broach. A welded side and face milling cutter with two fractures. A cutter broken in three places. Slitting saws.

Machine Design forFabricated and Welded Contruction, by F. Koenigsberger. (*Machinery, May, 13, 1943, Vol. 62, No. 1596, p. 512, 20 figs.*).

The use of struts when fabricating a structure for a milling machine. The sections tending to shrink and to resist shrinkage stresses in a fillet weld. Chart showing the considerable diminution of residual stresses by annealing at high temperatures. Heat treatment. Chart showing the relation of residual stresses to annealing temperatures and soaking time. How thermal distortion during welding may cause normal machining allowances to become rather critical. A preferred method. Economical efficiency of the design. Chart giving allowances for the developed lengths of bent plates and bars. An example of fabricated bedplate for a motor-compressor unit. Machine frames. Frame of milling machine. Formation of T-slots by the use of channels in the base plate of a radial drill. A press frame fabricated in steel by welding. Design of cast iron press frame. Fabricated gear box for milling machines.

WELFARE, SAFETY, ACCIDENTS.

Safety in Handling Aluminium Powders, by G. M. Babcock and F. B. Rethwisch. (*Chem. Met. Eng., January, 1943, Vol. 50, No. 1, p. 82*).

Careful and detailed instructions on how to avoid fires and explosions in works making pyrotechnics from Al flake and powder, and instructions for ways of dealing with fires when they do occur.

(*Communicated by the British Non-Ferrous Metals Research Association*).

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